USGS

Sound Waves

Coastal Science and Research News from Across the USGS

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Research

Collapsing Populations of Marine Mammals—the North Pacific's Whaling Legacy?

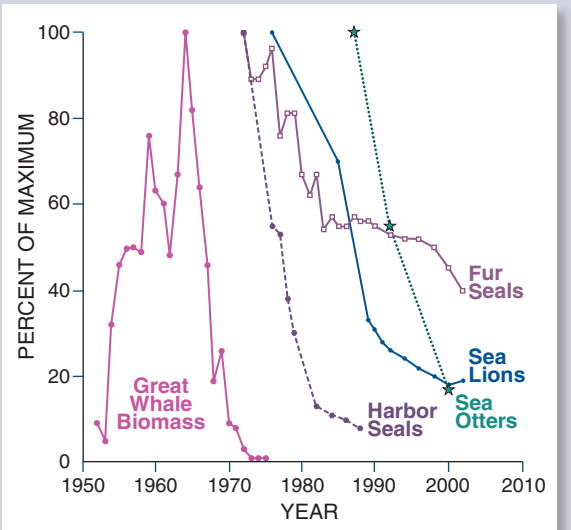
By Gloria Maender

The rapid removal of at least half a million great whales from the North Pacific Ocean by intensive industrial whaling more than 50 years ago may have unleashed a complex ecological chain reaction that has since rippled resoundingly from ocean to coastal ecosystems, according to a team of eight scientists, including **Jim Estes**, a U.S. Geological Survey (USGS) research ecologist and adjunct professor at the University of California, Santa Cruz. The team's paper on this subject, which prompted articles in newspapers around the country, was published in October in the *Proceedings of the National Academy of Sciences*.

The scientists believe that when great whales became scarce, their foremost natural predators, killer whales, turned to other marine mammals as primary sources of food, causing sequential declines in southwest Alaska during the 1960s and 1970s of first the harbor seals, followed by northern fur seals, Steller sea lions, and finally, in the 1990s, sea otters, as killer whales "fished down" the food web.

"During three decades of research in the Bering Sea and North Pacific Ocean, I watched other scientists struggle to understand the precipitous population declines of northern fur seals, harbor seals, and Steller sea lions, never imagining that my area of research—sea otters and kelp forests—might be affected by these changes," said **Estes**.

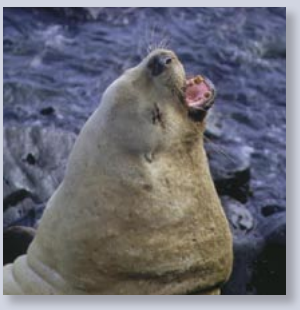
It was the decades of sea-otter research by **Estes** and colleagues that ultimately shed light on the pinniped declines. In about 1990, the Aleutian sea-otter population **Estes** studied plummeted, from an estimated 55,000-100,000 individuals in the 1980s to 6,000 individuals in 2000.



Sequential collapse of marine mammals in the North Pacific Ocean and southern Bering Sea.

*Male killer whale in Prince William Sound, Alaska. Photograph by **Janice Waite**, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center, National Marine Mammal Laboratory (NMML).*

Sea otter. Photograph from the U.S. Fish and Wildlife Service.



*Steller sea-lion adult male, yawning. Photograph by **Rolf Ream**, NMML, 1993, St. Paul Island.*

*Northern fur-seal pups. Photograph by **Rolf Ream**, NMML.*

Sleeping harbor seal. Photograph from NNML.

"By the late 1990s, sea otters occurred at such a low density throughout the archipelago that sea urchins were overgrazing the kelp forest," said **Estes**.

The absence of dead otters, as well as realizing that neither malnutrition nor disease could explain the declines—the remaining animals were healthy—led the scientists to consider predation as the cause of the deaths. Their conclusions in 1998 pointed to an oceanic problem that

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Sound Waves

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Deadline: The deadline for news items and publication lists for the December/January issue of *Sound Waves* is Thursday, November 20.
Publications: When new publications or products are released, please notify the editor with a full reference and a bulleted summary or description.
Images: Please submit all images at publication size (column, 2-column, or page width). Resolution of 200 to 300 dpi (dots per inch) is best. Adobe Illustrator© files or EPS files work well with vector files (such as graphs or diagrams). TIFF and JPEG files work well with raster files (photographs or rasterized vector files).

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Research, continued

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drove killer whales to switch from other prey to sea otters. They calculated that a killer whale on a steady diet of sea otters could consume as many as 1,825 otters in a year, and that as few as four whales on an exclusive sea-otter diet could have caused the documented sea-otter declines that occurred. The sea-otter decline led **Estes** and other scientists in this new study to wonder whether increased killer-whale predation might also explain the precipitous declines of northern fur seals, harbor seals, and Steller sea lions, and so they searched the oceans for the ultimate cause.

When modern industrial whaling arrived in the North Pacific in the late 1940s, several species of great whales had already been depleted in the region 50 to 100 years earlier. The new whaling fleets, from Japan and the Soviet Union, equipped with maritime technology developed during World War II, intensively sought fin whales, sei whales, and sperm whales, species that had not been taken in large numbers until after the war. By the mid-1970s, all of the great whales of the North Pacific were severely depleted.

Past beliefs regarding the abrupt collapses of seal and sea-lion populations in the 1960s and 1970s attributed the declines to limited or changing foods, stemming from climate change and competition with regional fisheries. Looking back at these events, however, this team of scientists found that their whale hypothesis was consistent with information on the abundance, diet, and foraging behavior of both predators and prey, as well as with feasibility analyses they conducted based on demographic and energetic modeling.

The scientists found that very small changes—as little as 1 percent of the total caloric intake—in killer-whale foraging behavior could account for both sea-otter and sea-lion declines.

The stunning magnitude of the caloric void that would have been left in the food chain by this whaling period has also strengthened the scientists' conviction about the origins of the chain of ecological events. When the great whales were abundant, their biomass may have been 60 times the combined biomass of all of the seals, sea lions, and sea otters. The great whales would have been able to sustain vastly more killer whales than could populations of pinnipeds and sea otters, **Estes** said.

The full citation of the recent article is Springer, A.M., Estes, J.A., van Vliet, G.B., Williams, T.M., Doak, D.F., Danner, E.M., Forney, K.A., and Pfister, B., 2003, Sequential megafaunal collapse in the North Pacific Ocean; an ongoing legacy of industrial whaling?: Proceedings of the National Academy of Sciences, v. 100, no. 21, p. 12,223-12,228 [searchable at URL **http://www.pnas.org/search.dtl**, by specifying DOI (Digital Object Identifier) 10.1073/pnas.1635156100]. Additional information about the article is available at URL **http://www.seaweb.org/PNAS2003/pnas.release.html**.

Fieldwork

Mapping of the Puerto Rico Trench, the Deepest Part of the Atlantic, is Nearing Completion

By Uri ten Brink

Three exploration cruises carried out in the Puerto Rico Trench within the past year have for the first time mapped the morphology of this entire tectonic-plate boundary, stretching from the Dominican Republic in the west to the Lesser Antilles in the east, a distance of 700 km (430 mi). (See related articles in November 2002 and February/March 2003 *Sound Waves*.)

The Puerto Rico Trench marks a boundary where two tectonic plates—the North American plate and the Caribbean plate—slide past each other, with the North American plate also subducting or sliding beneath the Caribbean plate. Water depths of more than 8 km (5 mi) make the Puerto Rico Trench the deepest part

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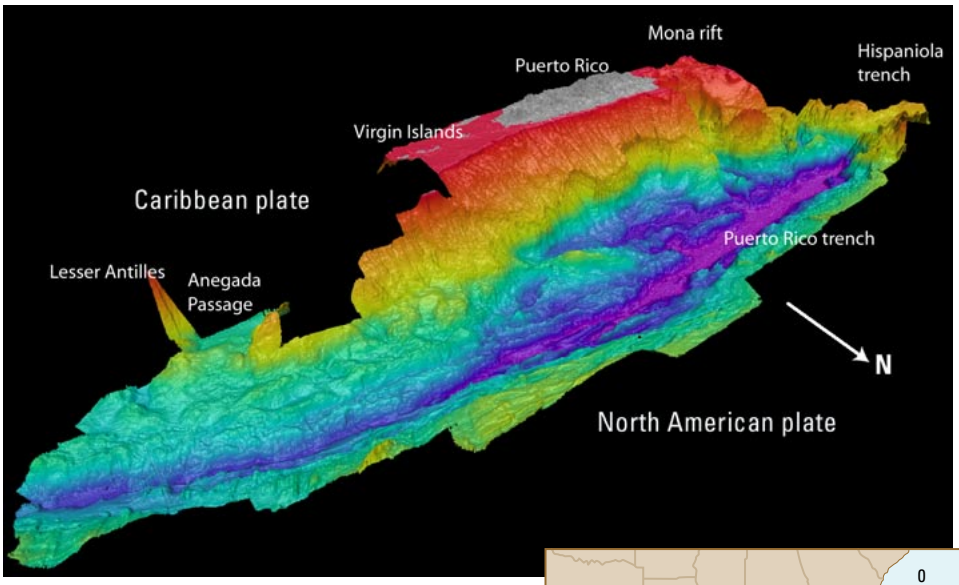
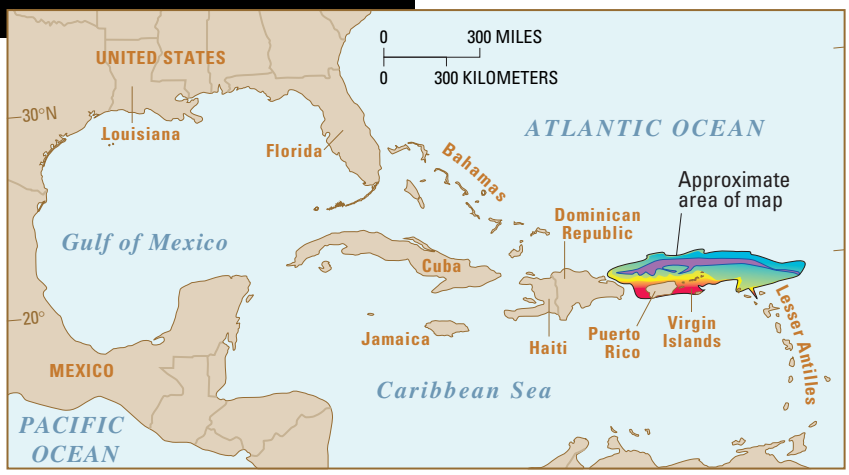
(Puerto Rico Trench continued from page 2)



Detailed sea-floor and land morphology of the northeast boundary of the Caribbean plate, constructed by using data from the USGS/NOAA multibeam cruises, lidar data, and a compilation of older soundings. View southwestward

The NOAA ship Ronald H. Brown, *sharing a dock with a Disney Cruise Line ship, in St. Maarten, Netherlands Antilles.*



of the Atlantic Ocean. It is less deep near the Lesser Antilles, where the component of subduction is larger. Many earthquakes and tsunamis resulting from the tectonic-plate motions have occurred in historical time in the northeastern Caribbean. Future such events will pose serious hazards to the growing population in this region, including approximately 4 million U.S. citizens of Puerto Rico and the Virgin Islands. The hazards to these islands are mainly in the form of submarine earthquakes, landslides, and tsunamis.

Observations from the three exploration cruises, coupled with computer modeling and with published global-positioning-system (GPS) results and earthquake focal mechanisms, have completely revised our view of the seismic and tsunami hazard from this plate boundary. While the seismic hazard appears to be less severe than was previously estimated from generic models, tsunami hazards may be more severe. The occurrence of continuous retrograde slumping (with new slumps occurring progressively farther upslope) on the Caribbean plate, the observation of large cracks on the slope north of Puerto Rico, and the discovery of giant landslides on the downgoing North American plate all highlight the potential for future submarine landslides, which could trigger damaging tsunamis.

The observations collected during these cruises have also contributed to our basic understanding of the mechanisms that govern plate tectonics, in this case, the creation of the Island of Puerto Rico and the deep Puerto Rico Trench to its north.

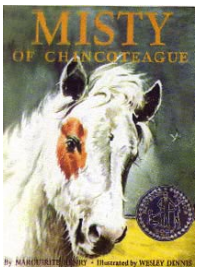
The three cruises were funded by the National Oceanic and Atmospheric Administration (NOAA)'s Office of Ocean Exploration and were carried out aboard the NOAA ship *Ronald H. Brown*. An area the size of the State of Maine was mapped during 21 survey days by the SeaBeam 2112 multibeam system, which was mounted on the keel of the ship. In addition to gathering data, these cruises also served to test and improve the performance of the system for future use by NOAA.

The most recent cruise took place between August 28 and September 4. Participants included U.S. Geological Survey (USGS) scientists **Uri ten Brink** (cruise chief scientist), **Bill Danforth**, and **Chris Polloni** from the USGS Woods Hole Field Center (WHFC). A uniform morphology data base for Puerto Rico and its surrounding seas at a grid interval of 150 m was produced by **Pilar Llanes Estrada**, a Ph.D. student visiting WHFC from the University of Madrid, by merging our new multibeam bathymetry data with lidar data around the coast of Puerto Rico (processed by **John Brock**, USGS, St. Petersburg, FL), the island topography, and a compilation of older low-resolution bathymetry. ❁

Studying Underwater Water in the Land of Misty—Chincoteague Bay, Maryland

By John Bratton

From August 14 to 22, 2003, a team led by U.S. Geological Survey (USGS) scientists undertook a complex field effort to study the occurrence and chemistry of submarine ground water beneath Chincoteague Bay, MD, as a followup to earlier geophysical studies. The area was made famous by **Marguerite Henry's** 1947 children's book (and later Disney movie) *Misty of Chincoteague*, about the wild horses that live on the adjacent barrier islands, Chincoteague and Assateague.

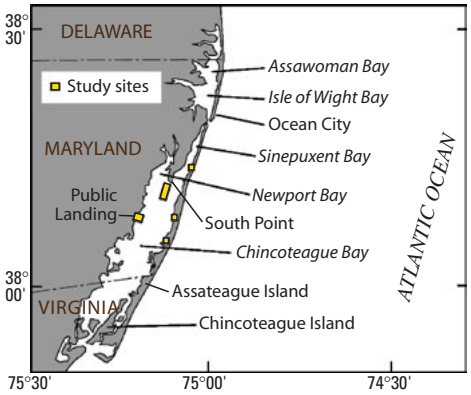


Chincoteague Bay is the site of nutrient over-enrichment that is of concern to its primary managers, the National Park Service and the Maryland Department of Natural Resources. Submarine discharge of ground water recharged in agricultural areas on land is suspected to be a major contributor of nitrogen to the bay. Nitrogen and other nutrients are, in turn, suspected of fueling blooms of macroalgae that foul boat propellers and may be smothering seagrass beds, critical nurseries for young fish, shrimp, and crabs.

The recent field study used several techniques to gather data about the submarine ground water beneath Chincoteague Bay. Offshore work consisted of drilling, geophysical logging, and sampling performed from a barge platform, augmented by onshore logging of existing wells. The maximum drilling depth reached by the barge rig was 72 ft beneath the sediment surface.

The field team included chief scientist **John Bratton** and contract research assistants **Sarah Kelsey** and **Dirk Koopmans** (USGS, Geology Discipline, Woods Hole, MA); **David Krantz** and **Abby Norton** (University of Toledo, Ohio); **John Earle** (USGS, Water Resources Discipline, Denver, CO); and **J.K. Böhlke** and **Craig Tobias** (USGS, Water Resources Discipline, Reston, VA). Drilling contractors from Hillis-Carnes Engineering Associates and a barge/tug pilot provided by Hi-Tide Marine Construction consistently overcame difficult mechanical, geologic, and meteorologic conditions to get the science done. Special thanks go out to National Park Service colleagues from Assateague Island National Seashore, **Brian Sturgis** and **Carl Zimmerman**, who provided logistical support, shuttle boats, and lodging.

The spud-barge platform with tug, excavator, and drill rig.



Map of the study area.

The fieldwork was conducted safely and efficiently and produced excellent scientific results. Noteworthy discoveries included the presence of a plume of fully fresh ground water, more than 25 ft thick, extending more than 1/2 mi offshore along the west side of the bay (near Public Landing), a similar plume at the north end of the bay (near South Point), hypersaline brines underlying part of Assateague Island, and a widespread buried peat at the base of the bay's Holocene sediment. Downhole gamma and electromagnetic-induction logs were obtained from eight locations. Ground water was sampled from nine temporary subestuarine wells, surface water was sampled from eight locations, and pore water was squeezed from 35 sediment samples. Additional analyses for age dating, nutrients, and stable isotopes will be performed over the coming months.

Wild horses, locally known as "ponies," graze along the roadway on Assateague Island.

USGS Scientist Invited to Address Meeting of Map Librarians

By Cheryl Hapke

U.S. Geological Survey (USGS) scientist **Cheryl Hapke** gave an invited talk to attendees at the Western Association of Map Libraries Fall 2003 Meeting, held from September 10 to 13, 2003, at the University of California, Santa Cruz (UCSC). **Cheryl's** talk, entitled "Coastal Cliff Erosion and Long-Term Beach Change in Monterey Bay, CA," described her use of recent and historical photographs to determine rates of seacliff erosion at various sites along Monterey Bay. Her results may help to identify areas prone to future seacliff failure and may lead to a better understanding of how certain events, such as earthquakes and large storms, interact with seacliff characteristics, such as rock type and pre-existing fractures, to trigger seacliff failure. **Cheryl** was one of several local scientists asked to address the group on how they use and rely on map libraries for their research. ❁

Oblique aerial photograph of the Long Marine Lab at UCSC. The Western Association of Map Libraries conference was held in the Seymour Center, the set of buildings at the far right.

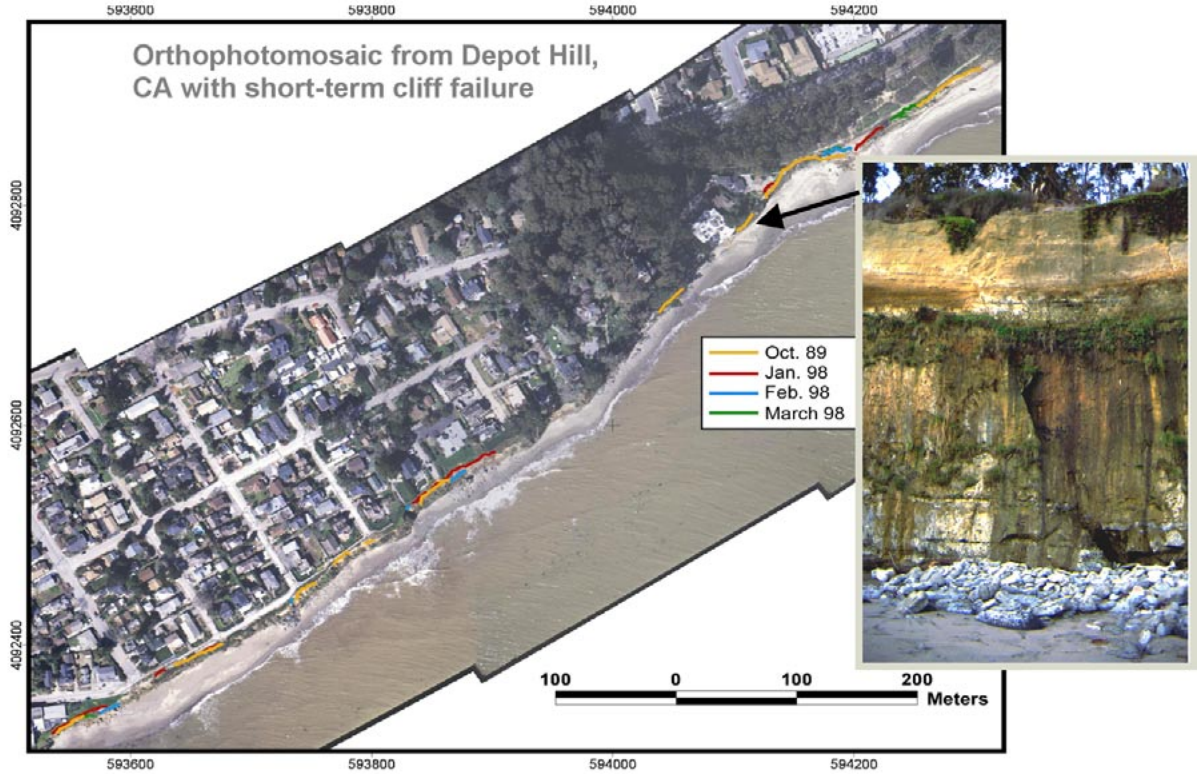


*Figure from **Cheryl's** talk at the Western Association of Map Libraries conference, dealing with mapping short-term coastal-cliff failures from both earthquakes (1989 Loma Prieta earthquake) and large storms (1997-98 El Niño). Data for this area and several other sites are available online as USGS Miscellaneous Field Studies Maps, at URLs **http://geopubs.wr.usgs.gov/map-mf/mf2398/**, **http://geopubs.wr.usgs.gov/map-mf/mf2399/**, and **http://geopubs.wr.usgs.gov/map-mf/mf2400/**.*

Coral Reef Project's Fact Sheet Wins 2003 Shoemaker Award

By Josh Logan

A U.S. Geological Survey (USGS) Fact Sheet entitled "U.S. Coral Reefs—Imperiled National Treasures" has won the USGS' 2003 Shoemaker Award for Communication Product Excellence in the print category. This 4-page fact sheet was created by the Coastal and Marine Geology Program (CMGP)'s Coral Reef Project and the USGS Western Publications Group (WPG). With a format that is both informative and visually appealing, the fact sheet outlines coral-reef formation and distribution and describes various threats to coral-reef health in U.S. waters.

Since they were first awarded in 1997, the Shoemaker Awards for Communication Product Excellence have been used to recognize USGS products that "demonstrate extraordinary effectiveness in communicating and translating complex scientific concepts and discoveries into words and pictures that capture the interest and imagination of the American public."

*This photograph of a coral reef in Florida appears on the first page of the award-winning USGS Fact Sheet 025-02, "U.S. Coral Reefs—Imperiled National Treasures." (Photograph copyright © **Sandra Edwards**, used with permission.)*

Congratulations to current and former CMGP members **Susan Cochran-Marquez**, **Michael Field**, and **Kevin Evans**, and to Western Publications Group members **James Hendley II**, **Peter H. Stauffer**, **Susan Mayfield**, **Sara Boore**, and **Jane Ciener** for their part in creating an outstanding publication.

To see the fact sheet on the Web, visit URL **http://geopubs.wr.usgs.gov/fact-sheet/fs025-02/**. To see the other recipients of the 2003 Shoemaker awards, visit this URL (accessible only to USGS employees): **http://internal.usgs.gov/OUTREACH/shoemaker/2003/winners.html**.

New Faces at the Pacific Science Center in Santa Cruz, CA

By Jane Reid

Several new people have joined the U.S. Geological Survey (USGS)'s Coastal and Marine Geology team at the Pacific Science Center in Santa Cruz, CA. Short biographies and a group photograph follow. We welcome these additions to our growing center in Santa Cruz!

Alan Allwardt's academic background is in structural geology (M.S., University of California, Santa Cruz [UCSC], 1979) and the history of earth sciences (Ph.D., UCSC, 1990). After working as a consulting geologist in Santa Cruz for 11 years, he enrolled in the School of Library and Information Science at San Jose State University to study archival principles and practices. He received a Master of Library and Information Science (MLIS) degree in 2003 and was recently hired as an information specialist at the USGS Pacific Science Center in Santa Cruz, CA, with additional ties to the USGS Field Center in Woods Hole, MA. **Alan** will be working on a catalog and thesaurus for the Marine Realms Information Bank (MRIB), a distributed library of World Wide Web resources initially developed by the USGS Field Center in Woods Hole in conjunction with the Woods Hole Oceanographic Institution. MRIB is one component of the USGS Coastal and Marine Knowledge Bank, with a pilot project currently underway to address the Monterey Bay area. He has lived in Santa Cruz—on and off—for more than 30 years.

Elaine Lakin-Wells is our new administrative assistant/secretary/facilities manager. She graduated from St. Mary's College of Moraga, CA, in 1983 with a B.S. in business administration and economics. In 1984, she started at Lockheed Missiles and Space as a department budget analyst for the Product Assurance Division of the company's Missile Systems Division (MSD). **Elaine** then became test director

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for the Device Signature Analysis testing. In 1987, she retired to start a family. She returned to the workforce as a temporary employee and in 1999 became a human-resources administration assistant at ATI Research Silicon Valley, Inc., a graphics company. In 2001, **Elaine** received a Human Resources Certificate from UCSC. While updating her computer-application skills at West Valley Community College, she assisted with the bookkeeping of the Villa Del Monte Water Co. **Elaine** is a California native and a long-time resident of the Santa Cruz Mountains—25-plus years.

Amy Draut is doing postdoctoral study through UCSC with **Dave Rubin**, working on eolian sediment transport in Grand Canyon and investigating the role of eolian sedimentation in the preservation of archeological sites there. She just moved to Santa Cruz after spending 10 years in Boston. **Amy** completed her Ph.D. through a joint program at the Massachusetts Institute of Technology and the Woods Hole Oceanographic Institution in March 2003. She spent the summer doing fieldwork in the Talkeetna Mountains of Alaska, studying volcaniclastic sedimentary rocks of a Jurassic island-arc complex. Her interests include geomorphology, coastal and near-shore sedimentology and stratigraphy, and the use of trace-element geochemistry to study subduction-zone processes.

From left to right: ***Elaine Lakin-Wells, Krystal Green*** *(see related article, this issue),* ***Alan Allwardt, Amy Draut, Omri Franco*** *(a student intern with* ***Curt Storlazzi*** *and* ***Jane Reid****), and* ***Dana Wingfield****.*

Dana Wingfield, who comes from Richmond, VA, graduated from the University of Virginia in May 2003 with a B.A. in environmental sciences. She is an intern at the Pacific Science Center with **Jane Reid** and **Curt Storlazzi**, working on two subtasks in the Western Region Benthic Habitat Project. For usSEABED, **Dana** is working toward the addition of new data, primarily from (but not limited to) the Gulf of Mexico. In addition, she is doing preliminary analysis of wave data for central California, in anticipation of integrating usSEABED data with these data to predict areas of seabed affected by waves, storms, and seasonal, annual, and interannual climatic conditions. **Dana** is applying to graduate school at UCSC, to begin in fall 2004. ❁

New Research Assistant to Study Landslides and Geologic Structures on the Big Sur Coast

By Cheryl Hapke

Krystal Green has recently joined the U.S. Geological Survey (USGS)'s Pacific Science Center in Santa Cruz, CA, as a research assistant who will be working with **Cheryl Hapke** for the next year. **Krystal** graduated from the University of California, Santa Cruz (UCSC), in June with a B.S. in earth sciences. She is already a familiar face at the Pacific Science Center, where she did an internship with **Cheryl** last winter and spring. In the coming year, **Krystal** will be involved in two major projects: with partial funding by the California Department of Transportation (Caltrans), she will be developing decadal snapshots of specific landslides along the Big Sur coast, using **Cheryl's** photogrammetric models. (See related article in August 2002 *Sound Waves*.) In addition, **Krystal** will begin processing hyperspectral data—measurements of reflected sunlight in many narrow wavelengths that reveal subtle variations invisible to the naked eye—from the Big Sur coast to use in mapping the regional distribution and density of geologic structures. **Krystal** has been hired through a cooperative agreement between the USGS and UCSC. We look forward to her continued contributions to the team. ❁

Krystal Green

New Administrative Assistant Joins Coastal and Marine Geology Team

By Bill Adams

The U.S. Geological Survey (USGS)'s Coastal and Marine Geology team in the Western Region recently welcomed **Annie Chau** as a new administrative assistant in the team's office in Menlo Park, CA. **Annie** comes to the USGS from private industry, where she held several jobs in production at high-technology firms. She switched to the health field when the high-tech industry went into a slump, and worked in a medical office just before joining us here at the USGS. After training in Menlo Park, **Annie** will transfer to the Pacific Science Center in Santa Cruz. She is excited about supporting the team's research and looks forward to learning more about it.❁

Annie Chau

Recently Published Articles

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